

## CLAIMS

1. Reinforcement unit (1) for reinforcing a footing element when laying pile foundations with a foundation pile (2) with at least one through-going longitudinal cavity (37), said reinforcement unit (1) includes a number of shaped and articulated reinforcement members (4) that are pivotally connected to a centrally arranged, annular element (5), so that the reinforcement unit (1) has a folded mounting position (fig. 2) and an extended position (fig. 4) of use, and that the reinforcement unit (1) is connected to the foundation pile (2) by one or more tension members (6), **characterised** in that said reinforcement unit (1) in said mounting position (fig. 2) is adapted for passing through said through-going longitudinal cavity (37) of said foundation pile (2).
2. Reinforcement unit (1) according to claim 1, **characterised** in that the tension members (6) are provided as wires, cables, threaded rods and/or round bar iron with bolt end.
3. Reinforcement unit (22) according to any of claims 1 – 2, **characterised** in that the reinforcement unit (22) furthermore includes a number of pipes (20), where a tension member (21) is disposed through each pipe (20) and fastened to a lower end of the pipe(20) and one or more reinforcement elements (26) with means for fastening.
4. Reinforcement unit (22) according to claim 3, **characterised** in that the reinforcement unit (22) furthermore includes a number of retainer elements (24), the retainer elements being (24) fastened to an upper end of one or more pipes (20) and provided with a cross-sectional shape with at least one retaining surface.
5. Reinforcement unit (22) according to claim 3 or 4, **characterised** in that the connection between pipe (20) and reinforcement members (26) are provided as a whole or partial eye connection (29).
6. Reinforcement unit (22) according to any of claims 3 – 5, **characterised** in that the means for fastening (23) a tension member (21) to a pipe (20) is one or more of the

following: a bolt joint, a press joint and/or a welding.

5 7. Reinforcement unit (1) according to any of claims 1 – 2, **characterised** in that the reinforcement unit (1) furthermore includes a number of retainer elements (8) that are fastened to a joining arrangement (9) in the tension member (6) and are provided with a cross-sectional shape with at least one retainer surface.

10 8. Reinforcement unit (1) according to claim 7, **characterised** in that the connecting arrangement (11) in the tension member (6) is one or more of the following: a spigot-and-socket joint, a press joint and/or a plate/bolt joint.

15 9. Reinforcement unit (1) according to any of claims 1 – 8, **characterised** in that the reinforcement unit (1) furthermore includes means for expanding (10) the reinforcement members (4), which means is one or more of the following: a spring ring, an eye connection, an explosion unit and/or a spreading element.

20 10. Reinforcement unit (1) according to any of claims 1 – 9, **characterised** in that the reinforcement members (4) are annular so that both ends of the reinforcement rods are movably arranged around the centrally arranged annular element (5).

25 11. Reinforcement unit (1) according to any of claims 1 – 9, **characterised** in that the reinforcement elements (4) each are shaped as a segment of a ring so that they, when the reinforcement unit (1) is folded, form a ring corresponding to an inner diameter of at least one through-going longitudinal cavity (37) in the foundation pile (2), and when the reinforcement unit (1) is expanded, form an approximately circular ring having a diameter equal to or greater than the diameter of the bottom (18) of the foundation pile (2).

30 12. Reinforcement unit (1) according to any of claims 1 – 9, **characterised** in that the reinforcement members (4) are formed by a network of rods and/or wires (12).

13. Foundation pile (36) with a footing element, which is reinforced with a reinforcement unit (46) according to any of claims 1 – 12, including at least one through-going

longitudinal cavity (37), **characterised** in that said footing element optionally includes a pile foot (38) and said reinforcement unit (46) and/or said pile foot (38) is connected with the foundation pile (36) with one or more tension members (40).

5      14. Foundation pile (36) according to claim 13, **characterised** in that in the foundation pile (36) there is provided a number of through-going, longitudinal side ducts (39) that are disposed with largely uniform spacing from the cross-sectional centre of the foundation pile (36), that in each side duct (39) there is provided a tension member (40), that each tension member (40) is fastened downwards with means for fastening  
10      (41) to a reinforcement unit (46) including a pile foot (38), and that the pile foot (38) is releasably connected to the preferably cylindric part of the foundation pile (36) by means of the tension members (40).

15      15. Foundation pile (36) according to any of claims 13 - 14, **characterised** in that the tension members (40) have at least one free section (50) between the lower edge of the foundation pile (36) and the pile foot (38).

20      16. Foundation pile (36) according to any of claims 13 - 15, **characterised** in that the means for fastening (41) the tension members (40) to the pile foot (38) is one or more of the following: a bolt joint, a press joint, a sleeve, a casting and/or that a preferably U-shaped duct is provided inside the pile foot (38) through which a tension member (40) may be passed.

25      17. Foundation pile (36) according to any of claims 13 - 16, **characterised** in that the pile foot (38) upwards has a top element (44) which in its basic form corresponds to the cross-sectional shape of at least one through-going longitudinal cavity (37), and that the top element (44) has a tapering shape (45) upwards which is symmetric about the centre line of the pile foot (38).

30      18. Foundation pile (36) according to any of claims 13 - 17, **characterised** in that the pile foot (38) is provided downwards with a tapering shape (43) and/or a flat disc shape (59).

19. Foundation pile (36) according to any of claims 13 – 18, **characterised** in that a loosely folded reinforcement unit (46) is provided at the lower end of the through-going longitudinal cavity (37), including a number of articulated reinforcement members (47) that at one end are movably arranged around a centrally arranged annular element (48), and that the free end of each reinforcement member (47) is shaped so that the end at least projects in over the centre line of the top element (44) of the pile foot (38).

20. Foundation pile (36) according to any of claims 13 – 19, **characterised** in that recesses (49,54) are provided in the pile foot (38) and/or the lower part of the preferably cylindric section of the foundation pile (38) for accommodating the free part (50) of the tension members (40).

21. Foundation pile (67) according to any of claims 13 – 20, **characterised** in that at least one through-going longitudinal cavity (69) is connected at one or more points with the outer side of the foundation pile by one or more transverse and downwards directed filling ducts (70).

22. Foundation pile (67) according to any of claims 13 – 21, **characterised** in that the foundation pile (67) is designed with one or more external reinforcements (71).

23. Foundation pile (67) according to any of claims 13 – 22, **characterised** in that the at least one through-going longitudinal cavity (69) of the foundation pile (67) is designed with a screw thread at the uppermost section.

24. Foundation pile (67) according to any of claims 1 – 23, **characterised** in that the foundation pile (67) is used with an adapter (80) which is formed with a first mounting ring (82) for fastening against a foundation arrangement and a second mounting ring (81) for fastening against a tower member, where first (82) and second mounting rings (81) are connected with one or more connecting elements (83).

25. Method for placing a foundation pile (2) according to any of claims 13 – 24, and reinforcing a footing element with a reinforcement unit (1) according to any of claims

1 – 12, where the foundation pile is placed in desired position, either by pressing or driving down or by placing in pre-drilled holes, **characterised** in that a folded reinforcement unit (1) is pressed down through the at least one through-going longitudinal cavity (37) in the foundation pile (2), when the reinforcement unit (1) reaches the bottom of the foundation pile (2), it is pressed a distance farther down, and the means for expanding (10) the reinforcement members (4) are activated, thereby forming a network at least consisting of the reinforcement members (4), and curable filler (30) is pressed down through the at least one through-going longitudinal cavity (37) in the foundation pile (2), so that the lower part (18) of the foundation pile (2) and the expanded reinforcement unit (1) are cast in one for formation of a reinforced footing element with larger dimension than the outer dimension of the foundation pile (2).

26. Method according to claim 25, **characterised** in that after placing the foundation pile (36), the pile foot (38) is pressed and/or driven farther down into the ground with a piston (51) and/or a driving tool, where the distance between the pile foot (38) and a lower part of the foundation footing corresponds at the most to the length of the free section (50) of the tension members (40).

27. Method according to claim 25, **characterised** in that, depending on the ground conditions before pressing the folded reinforcement unit (22) down, there is formed a cavity (3) under the lower part (18) of the foundation pile (2) with a ground preparation unit (19).

28. Method according to any of claims 25 – 27, **characterised** in that the reinforcement unit (22), when reaching the bottom of the foundation pile (2), is pressed down into the underlying cavity (3) until the retainer members (24) at the upper part of the reinforcement unit (22) are falling in position against the inner side of the foundation pile (2), and where subsequently the reinforcement members (26) are pulled so as to ensure that the reinforcement unit (22) and the bottom (18) of the foundation pile (2) are closely joined.

29. Method according to any of claims 25 – 28, **characterised** in that the means for expanding (10) the reinforcement members (22) is a spring ring, whereby the pipes

(20) are pressed outwards, and the reinforcement member (26) will thereby, via the eye connection (29), be forced outwards, so that a network consisting of pipes (20), reinforcement members (26) and the centrally arranged annular element (27) is formed.

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30. Method according to any of claims 25 – 28, **characterised** in that the means for expanding (10) the reinforcement members (4) is a spreading element arranged so that it is controlling the reinforcement members (4) of the reinforcement unit (1) when they are falling outwards due to the force of gravity when the reinforcement unit (1) reaches the cavity (3) under the foundation pole (2), so that a network consisting of reinforcement members (4) and the centrally arranged annular element (5) is formed.

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31. Method according to any of claims 25 – 28, **characterised** in that the expansion of the reinforcement members (22) occurs when the piston (28) is pressed down on the annular element (27) of the reinforcement unit (22), after which the reinforcement members (26) are passed through the connection (29) mounted between pipes (20) and reinforcement member (26), and whereby the reinforcement members (26) are pressed outwards.

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32. Method according to any of claims 25 -28, **characterised** in that the means of expansion (10) is an exploding unit, whereby the reinforcing members (26) are pressed outwards as a consequence of the explosion.

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33. Method according to claim 25 – 27, **characterised** in that for formation of a cavity (3) in connection with the lower part (18) of the preferably cylindric foundation pile (2), the following may be done:

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- a ground preparation unit (19) is passed down through the working duct (37),
- the ground preparation unit (19) works the surrounding earth layer (17) under the foundation pile (2),
- a cavity (3) is formed out from the foundation pile (2),
- the ground preparation unit (19) is drawn up through the working duct (37).

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34. Method according to claim 25, **characterised** in that curable filler (52) is injected

through the at least one longitudinal cavity (37) and out through filler ducts (70) connected therewith for forming one or more beads (68) around the outer circumference of the foundation pile (67).

- 5 35. Method according to claims 25 – 32, **characterised** in that liquid impeding filler material is injected into the cavity (3) under the foundation pile (36) before placing the reinforcement unit (46) and casting the footing element (53).